Advanced Research

Funding Schedule by Activity

(dollars in thousands)

	FY 2004	FY 2005	FY 2006	$ Change	% Change
Advanced Research					
Coal Utilization Science	11,581	17,552	8,000	-9,552	-54.4%
Materials	10,809	10,848	8,000	-2,848	-26.3%
Technology Crosscut	11,326	10,355	10,500	+145	+1.4%
University Coal Research	2,863	2,958	3,000	+42	+1.4%
HBCUs, Education & Training	954	986	1,000	+14	+1.4%
Total, Advanced Research	37,533	42,699	30,500	-12,199	-28.6%

Description

The mission of the Advanced Research subprogram is to serve as a bridge between basic and applied research to foster the development and deployment of innovative systems for improving efficiency and environmental performance, while reducing costs, of Advanced Coal and Power Systems.

Benefits

Advanced Research provides the means by which advanced concepts are transformed into future working technologies. It is crosscutting in nature and supports all Fossil Energy Coal and Power Systems in its development of highly efficient power plants with zero emissions and also FutureGen. Improvement of our energy infrastructure, which includes power plants, power transmission systems, environmental protection and remediation efforts, is dependent on research. This research must produce technologies that meet the performance specifications for hostile operating conditions, economic constraints of advanced industrial applications, and public demand for a cleaner environment, reliability, and low consumer cost. These constraints require that Advanced Research develop fundamental understandings of relationships among energy processes, their performance requirements, and the environment through a greater understanding of the physical, chemical, biological and thermodynamic barriers to achieving these goals. Especially important research is being conducted in the areas of materials research, sensors and controls, and computational energy science that is expected to reduce the requirement for constructing many expensive pilot plants.

Background

The Advanced Research Program works to create public benefits through two types of activities. The first is a set of crosscutting studies and assessment activities in environmental, technical and economic analyses, coal technology export and international program support. The public benefits from these activities because the improvement of programs and regulatory activities will help to maximize their benefits and lower their costs. The second is a set of crosscutting fundamental and applied research programs which include coal utilization science, materials, bioprocessing of coal, and university-based

research. The public benefits from these activities because the long-term, high-risk activities target areas where industry is not able to invest.

These high risk research activities can produce public benefits such as increased energy efficiency, reduced pollution, or more reliable power supplies. For example, the university-based research programs include the University Coal Research program and the Historically Black Colleges and Universities and Other Minority Institutions (HBCU/OMI) program, address the full spectrum of fossil utilization research and development, technology transfer, outreach, and private sector partnerships.

In the crosscutting studies and assessments subprograms, the thrusts of international program support, environmental activities, coal technology export, and technical and economic analysis are to complement and enhance all Fossil Energy endeavors by providing both financial and technological leverage. International involvement is limited to those selected areas where it has been determined that the U.S. will benefit at least to the extent it contributes. Fossil Energy, through these activities, always attempts to encourage the leveraging of research and development funds while promoting U.S. industrial interests and to use them as opportunities to achieve responsible international consensus and opinion on technical business assessment and policy issues.

The crosscutting fundamental and applied research programs focus upon developing the technology base in the enabling science and technology areas that are critical to the successful development of both superclean, very high efficiency coal-based power systems and coal-based fuel systems with greatly reduced or no net emissions of CO_2. These systems are encompassed in the Zero-emission compatible energyplexes and the FutureGen initiative. Advanced Research seeks a greater understanding of the physical, chemical, biological and thermodynamic barriers to achieving economic, technologic, and environmental goals and identifies ways to overcome those barriers. The program is directed to specific underlying fundamental scientific and engineering problems closely connected to long-range Fossil Energy objectives.

An Advanced Research focus area on Computational Energy Sciences has been established at the National Energy Technology Laboratory (NETL). This focus area will conduct simulations and modeling activities to produce a “technology base” from which the energy plants of the future will be designed, built and operated.

The Coal Utilization Science subprogram focuses on research pertinent to all coal utilization systems, with specific attention paid to increasing our knowledge of the principal mechanisms that control coal conversion processes. It will address issues affecting the utilization of coal, and its primary thrust is in support of the development of the Zero-emission compatible concept. It will involve novel concepts for CO_2 capture and sequestration, such as mineral carbonation, and virtual simulations and modeling of components and subsystems. It will also include research on instrumentation and diagnostics to support the development of advanced controls and sensors.

High performance Advanced Materials and equipment are essential to advanced coal technologies. Thus, the thrust of the Advanced Materials subprogram is to develop materials for advanced gas separation and particulate removal, as well as to develop solutions to materials performance barriers unique to very high temperature, highly corrosive coal combustion and gasification environments.

Exploratory research and innovation to maximize the use of coal in environmentally preferable ways is typified by the bioprocessing of coal subprogram. The focus of the Biotechnology subprogram is to conduct biological research to produce clean fuels and to reduce greenhouse gas emissions (NO_x, SO_x, and CO_2) from existing and new powerplants.

The University Coal Research and HBCU/OMI subprograms are both education and training programs that support competitively awarded research grants at U.S. colleges and universities to address Fossil Energy's highest priority research needs.

Detailed Justification

(dollars in thousands)

	FY 2004	FY 2005	FY 2006
Coal Utilization Science	**11,581**	**17,552**	**8,000**
▪ **Coal Utilization Science (Core)**	**6,762**	**13,116**	**7,620**

In FY 2006, conduct research that supports development of highly efficient and clean power plants, focusing on the reduction or elimination of adverse environmental impacts of coal use. Sensors and Controls: Continue to develop a new class of sensors selected through a FY 2003/2004 BBFA solicitation that are capable of monitoring under the harsh operating conditions of ultra-clean fossil energy systems including FutureGen. Proceed to prototype development of sensor projects based on feasibility test evaluations. Enabling Technologies: Initiate projects selected under FY 2005 solicitation targeting critical areas of power plants with near-zero emissions and FutureGen. Continue mechanistic 3D modeling and stochastic modeling and model integration development for advanced power systems. Continue to investigate basic combustion and gasification chemistry to discern rates and mechanisms that control emissions behavior of coal under advanced and conventional combustion/gasification conditions to minimize NO_x, SO_x, air toxics, and other pollutants in support of clear skies initiative. Develop conceptual geochemical model of magnesium silicate carbonation for CO_2 sequestration and demonstrate CO_2 brine carbonation with core geological reservoir host rocks. No funds is requested for the Arctic Energy Office. *Participants include: NETL, SNL,CMU,ARC,Ohio State U., Uof Fla, MSU, Nuonics, Prime Photonics, REI, SRI, Miss. State U., SRD, TBD*

In FY 2005, conduct research that supports the development of highly efficient and clean power plants, focusing on the reduction or elimination of adverse environmental impacts of coal use. Sensors and controls: Complete prototype development and testing of sensors critical to enhancing and controlling plant efficiencies and emissions. Continue to develop new class of sensors based on projects selected through FY 2002, FY 2003, and FY 2004 solicitations that are suitable for monitoring in harsh conditions that will enable the operation of ultra-clean fossil energy systems. Enabling Technologies: Complete development of computational workbench for Zero-emission compatible systems. Initiate mechanistic 3D modeling of Zero-emission compatible plant. Continue to investigate basic combustion and gasification chemistry to discern rates and

mechanisms that control emissions behavior of coal under advanced and conventional combustion/gasification conditions to efficiently minimize NO_x, SO_x, air toxics, and other pollutants in support of the clear skies initiative. Complete integration of mechanical, chemical, and chemico-mechanical pretreatment into CO_2 mineral carbonation process. Continue support for the Arctic Energy Office. *Participants included: NETL, SNL, CMU, U. of Pittsburgh, ARC, Ohio State U., REI, U. of FL, MSU, U. of Alaska..*

In FY 2004, conducted research to enable reduction or elimination of environmental impacts of coal use; focus on greenhouse gases that may affect global climate change. Sensors and Controls: Completed pilot-scale tests of select gasification and combustion sensors; complete feasibility tests of other sensor development projects selected under FY 2002 solicitations. Selected fewer projects for award under FY 2003 solicitations for fundamental sensor devices including applications of nanotechnology. Continued stochastic modeling and systems analysis for zero emissions power plants concepts and FutureGen. Completed Round 2 course grid simulations and computational workbench projects and continued projects selected under round III of broad-based agency Vision 21 solicitation to develop critical enabling technologies for advanced zero emissions power and fuel systems. Investigated basic combustion and gasification chemistry to discern rates and mechanisms that control emissions behavior of coal under advanced and conventional combustion gasification conditions to efficiently minimize NO_x, SO_x, air toxics, and other pollutants in support of the Clear Skies Initiative. Developed predictive models as a tool for designers of Vision 21 plants. Demonstrated the feasibility of the in-situ CO_2 mineral sequestration concept through laboratory tests of drill-core samples and maintained minimum levels of fundamental lab-scale research to addresses process design issues. Continued support for the Arctic Energy Office Activities. *Participants included: NETL, SNL, CMU, U. of Pittsburgh, Princeton, ARC, University of Alaska.*

- **Mercury Control**..... **1,800** **300** **300**

In FY 2006, continue projects selected under FY 2004 solicitation for fundamental mechanisms that effect mercury control. Continue to develop real time mercury emissions monitor with capability for speciation. *Participants include: SNL, Purdue U., GTI, U. of Arizona, URS.*

In FY 2005, implement projects selected under FY 2004 solicitation. Continue to develop real time mercury emissions monitor with capability for speciation. *Participants included: Purdue U., GTI, U. of Arizona, URS, SNL.*

In FY 2004, conducted fundamental research on mercury formation and control. As part of a new sensors and control solicitation, developed sensors to detect and monitor mercury emissions. Developed atmospheric modeling (plume chemistry and deposition) with a focus towards mercury. *Participants to be determined.*

(dollars in thousands)

FY 2004	FY 2005	FY 2006

- **Center for Zero Emissions Coal Research** **2,900** **3,960** **0**

  In FY 2006, no new funding requested. Support for the Strategic Center for Zero Emissions Coal Research will continue with funds made available in FY 2005.

  In FY 2005, continue to conduct research for advanced coal programs and FutureGen at the Strategic Center for Zero Emissions Coal Research. Funds provided in FY 2005 are sufficient to support this effort through FY 2006. *Participants included: Montana State U., WVU, PNNL, LANL, NETL.*

  In FY 2004, created a Strategic Center for Zero Emission Coal Research at the High-Temperature Electrochemistry Center (HiTEC) to conduct research in support of advanced coal programs and FutureGen, and to enhance collaboration between Universities and National Labs. *Participants included: Montana State Univ., NETL.*

- **Program Support** **119** **176** **80**

  Fund technical and program management support.

Materials **10,809** **10,848** **8,000**

- **High Temperature Materials Research** **5,394** **5,899** **4,596**

  In FY 2006, develop strong, tough and oxidation resistant materials capable of service temperatures approaching 1600°F. Apart from the environmental aspects of the effluent from coal combustion, major concern from the systems standpoint is the aggressiveness of the combustion environment toward structural components. This experimental program will be aimed at developing a scientific understanding of corrosion mechanisms as a function of alloy composition and deposition chemistry, and at quantitatively determining the scaling and internal penetration of sulfur and oxide species into the alloys. *Participants include: ANL, INEEL, ORNL, Ames.*

  In FY 2005, develope a new generation of corrosion resistant high temperature alloys and refractories that will be used as hot components in advanced fossil energy combustion and conversion systems. Perform laboratory research accompanied by testing of the alloys in actual power plant conditions. Novel nano-science approaches were developed for separating hydrogen from product streams that are generated during coal gasification, methane partial oxidation, and water-gas shift reactions. A substantial part of the nano-science for separation is research on materials and their microstructure, for example, the development of materials used as molecular sieves to separate hydrogen from the test of the gas. Demonstrate stability of proton-conducting ceramics in atmosphere of coal-derived gas and operated membrane reactor to produce low cost hydrogen from coal. *Participants included: ANL, INEEL, ORNL, Ames, LBNL, TBD.*

(dollars in thousands)

FY 2004	FY 2005	FY 2006

In FY 2004, continued to develop improved materials for high-temperature, high-pressure heat exchangers, high-temperature inorganic membranes, refractories, and activated carbons for next generation, ultra clean fossil energy power systems. Continued to develop new alloys to include intermetallics, advanced austenitic alloys, advanced ferritic alloys, and oxide-dispersion-strengthened alloys. Functional materials research addressed hot-gas particulate filters, and physical absorbents, i.e, advanced carbons and non-destructive evaluation techniques. *Participants included: ANL, INEEL, ORNL, Ames, NETL, LBL.*

- **Materials for Ultra Supercritical and Gas Separation Systems** **4,489** **4,841** **3,324**

In FY 2006, develop alloys (e.g., for boiler tubing materials) for ultra supercritical (USC) systems with operating temperatures raised to 1460^{o}F and ensure the weldability of these high temperature materials. The lack of materials with the necessary fabricability, fracture toughness, and adequate resistance to creep, oxidation, corrosion, and thermal fatigue at these higher steam temperatures and pressures currently limit the operation of pulverized coal-fired plants at the higher efficiency advanced USC steam conditions. Pursue breakthrough concepts to develop materials (to include membranes) for achieving very low cost hydrogen and oxygen separation from mixed gas streams and for stabilizing greenhouse gases for next generation energy plants such as FutureGen. *Participants include: ORNL, PNNL, Energy Industries of Ohio, ARC, ANL, INEEL, Ames, LANL, Siemens-Westinghouse.*

In FY 2005, identify improved alloys, fabrication processes and coating methods that will permit boiler operation of steam temperatures up to 1400^{o}F and steam pressures up to 5400 psi. Work with alloy developers, fabricators, equipment vendors and power generation plant operators to obtain cost targets for the commercial deployment of alloys and processes developed. Define issues impacting designs that can permit power generation at steam temperatures greater than or equal to 1460^{o}F. Identify materials needed to develop steam turbines capable of operating at ultra supercritical temperature and pressure conditions and developed a plan to evaluate and qualify materials for the critical components of such turbines. Increase permeance of new membrane materials for achieving very low cost hydrogen and oxygen separation from mixed gas streams achieving repeatability with defect-free membranes, and employed techniques that can be used to manufacture on a large scale. Study impact of new materials and processes for stabilizing greenhouse gases for next generation energy plants (such as oxygen-fired combustion). *Participants included: LANL, ORNL, ARC, UCSD, PNNL, Energy Industries of Ohio, Siemens-Westinghouse.*

In FY 2004, developed alloys for ultra supercritical systems with operating temperatures raised to 1400^{o}F; ensure the weldability of these high temperature materials, and developed the base materials technology needed to develop steam turbines capable of operating at the ultra supercritical temperature and pressure conditions which are critical to increasing the efficiency via ultra supercritical cycles. Pursued breakthrough concepts to develop materials for achieving very

low cost hydrogen and oxygen separation from mixed gas streams and for stabilizing greenhouse gases for Zero-emission plants. Accomplishments include the screening and identification of potential ceramic and other class materials and processes (e.g., clathrates, and a declassified uranium enrichment process that applies gaseous diffusion techniques in uranium separation to hydrogen separation) for hydrogen separation, and ionic transport membrane materials for oxygen separation. *Participants included: LANL, ORNL, PNNL, ARC, Energy Industries of Ohio, Ames, UCSD.*

- **Materials for Mercury Control** **500** **0** **0**

  In FY 2006 and FY 2005, no funding is requested for this activity.

  In FY 2004, evaluated novel materials for the conversion or removal of mercury from process streams.

- **Materials for Advanced Fuel Cell Concepts** **315** **0** **0**

  In FY 2006 and FY 2005, no funding is requested for this activity.

  In FY 2004, developed advanced concepts that utilize carbon material from coal directly in a fuel cell. Such a concept will permit high and intermediate temperature fuel cells to directly convert carbon to electrical power without the need of an intermediate coal gasification step. National Laboratories may also contribute materials research in support of other advanced fuel cell concepts.

- **Program Support** **111** **108** **80**

  Fund technical and program management support.

Technology Crosscut **11,326** **10,355** **10,500**

- **Coal Technology Export** **988** **986** **1,000**

  In FY 2006, intensify the facilitation of the development and deployment of Zero Emissions Technologies for fossil fuels internationally working with IEA Headquarters. Increase emphasis on pursuing opportunities identified by the World Energy Council Committee on Cleaner Fossil Fuel Systems and the Southern States Energy Board for the international sale and deployment of U.S. clean coal technologies and advanced power systems. Strengthen established partnerships and pursue the establishment of additional effective partnerships to advance U.S. interest in environmental protection by promoting deployment of cleaner energy systems through training, conferences, site visits and information and technical exchanges on clean power systems, best practices, privatization with targeted utilities and governments, and advising countries on identification and elimination of barriers for deployment of cleaner coal and power systems. Promote the deployment of carbon capture and storage technologies worldwide. Initiate the

implementation of Clean Energy/Industrial Ecology Projects in developing countries as a means of Mitigating CO_2 emissions growth as these countries expand electrification. *Participants to be determined.*

In FY 2005, intensify the facilitation of the development and deployment of Zero Emissions Technologies for fossil fuels internationally working with IEA Headquarters. Continue compounding the pursuit of opportunities identified by the World Energy Council Committee on Cleaner Fossil Fuel Systems and the Southern States Energy Board for the international sale and deployment of U.S. clean coal technologies and advanced power systems. Strengthen established partnerships and pursue the establishment of additional effective partnerships to advance U.S. interest in environmental protection by promoting deployment of cleaner energy systems through training, conferences, site visits and information and technical exchanges on clean power systems, best practices, privatization with targeted utilities and governments, and advising countries on identification and elimination of barriers for deployment of cleaner coal and power systems. Promote the deployment of carbon capture and storage technologies worldwide, and provided support for the Carbon Sequestration Leadership Forum. Initiate the implementation of Clean Energy/Industrial Ecology Projects in developing countries as a means of Mitigating CO_2 emissions growth as these countries expand electrification. *Participants to be determined.*

In FY 2004, sustained continued support for collaboration of zero emission technologies internationally. Intensified the pursuit of opportunities identified by the World Energy Council Committee on Cleaner Fossil Fuel Systems and the Southern States Energy Board for the international sale and deployment of U.S. clean coal technologies and advanced power systems. Continue pursuit of the establishment of effective partnerships to advance U.S. interests in environmental protection by promoting deployment of cleaner energy systems through training, conferences, site visits and information and technical exchanges on clean power systems, best practices, privatization with targeted utilities and governments and advising countries on identification and elimination of barriers for deployment of cleaner coal and power systems. This funding level supported fewer conferences and site visits when compared to FY 2003. *Participants to be determined.*

- **Bioprocessing of Coal** **1,482** **1,480** **1,500**
  - **Bioprocessing of Coal** **1,467** **1,465** **1,485**

    In FY 2006, complete testing at large scale (power plant) toxin process to safely control zebra mussels as a means of improving the efficiency and reliability of existing power plants. (Transfer technology to innovation for existing plants program for further development). Complete development of technical protocol for screening marine microalgae for maximum biofixation and its conversion into alternative fuels. Evaluate processes for generating hydrogen from fossil fuels. Continue to investigate global and natural CO_2 sequestration. Continue bioremediation of coal to reduce mercury emissions from power plants. Investigate

novel bioprocessing research focusing on investigations of influence of microorganisms on the fate of mercury from coal ash. Initiate development of biosensors for detections of pollutants using light emitting proteins. *Participants include: ORNL, INEEL, NY Museum, NETL.*

In FY 2005, continue testing at large scale (power plant) toxin process to safely control zebra mussels as a means of improving the efficiency and reliability of existing power plants. Continue development of technical protocol for screening marine microalgae for maximum biofixation and its conversion into alternative fuels. Complete development of bench scale testing of biohydrogen from carbon containing waste products to determine food sources that will support microbial growth and hydrogen production. Continue to investigate global, and natural CO_2 sequestration. Demonstrate whitings catalyzed CO_2 fixation at pilot scale. Investigate production value of added chemicals via nonaqueous biocatalysis. Continue bioremediation of coal to reduce mercury emissions when burned in power plants. *Participants include: ORNL, INEEL, PNNL, NY State U., NETL.*

In FY 2004, initiated large scale testing to develop toxin to safely control zebra mussels as a means of improving the efficiency and reliability of existing power plants. Initiated development of technical protocol for screening marine microalgae for maximum biofixation and its conversion into alternative fuels. Investigated global, natural CO_2 mitigation strategies such as whitings and ocean scale algae sequestration. Continued development of biogeochemical environmental remediation of ammonia discharges associated with coal wastes from existing power plants. In furtherance of launching the hydrogen economy, investigated biohydrogen generation from carbon containing waste products to determine food sources that will support microbial growth and hydrogen production, conduct tests at bench scale. Investigated novel bio-environmental remediation processes related to coal conversion technology. *Participants include: ORNL, INEEL, U. State of NY, Cal. State U.*

- **Program Support**..... **15** **15** **15**

  Fund technical and program management support.

- **Environmental Activities**..... **1,975** **1,972** **2,000**

In FY 2006, continue analysis of issues associated with air and water quality, solid waste disposal, and toxic substances, and global climate change. Continue emission trends and forecast studies. *Participants include: ANL, ICF, Resource Dynamics, TMS, PNNL.*

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(dollars in thousands)

FY 2004	FY 2005	FY 2006

In FY 2004, continued analyses of issues associated with air and water quality, solid waste disposal, and toxic substances, and global climate change. Continued emission trends and forecast studies. *Participants include: ANL, ICF, Resource Dynamics, TMS, PNNL.*

- **Technical and Economic Analyses** **988** **986** **1,000**

In FY 2006, continue studies supporting multi-year planning FE strategy and program formulation; conduct studies on issues that crosscut FE programs including strategic benefits of and new markets for fossil fuel technology. Conducted critical studies to identify major challenges, "leapfrog" technologies, and advanced concepts that are applicable to fossil energy systems, and have the potential to improve their efficiency, cost, and/or environmental performance. *Participants include: ANL, ICF, EIA, Resource Dynamics, TMS.*

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FY 2004 funding continued studies supporting multi-year planning FE strategy and program formulation; conducted studies on issues that crosscut FE programs including strategic benefits of and new markets for fossil fuel technology. Conducted critical studies to identify major challenges, "leapfrog" technologies, and advanced concepts that are applicable to fossil energy systems, and have the potential to improve their efficiency, cost, and/or environmental performance. *Participants include: ANL, ICF, EIA, Resource Dynamics, TMS.*

- **International Program Support** **988** **986** **1,000**

In FY 2006, continue Fossil Energy's commitment to the International Energy Agency (IEA) program support. Continue to provide leadership, direction, cooperation and coordination of office activities with other Federal agencies, state and local governments, energy trade associations, and the energy industry. Continue preservation and enhancement of active relationships with national and international organizations such as the World Energy Council (WEC), United States Energy Association (USEA), Southern States Energy Board (SSEB), and universities and other non-governmental organizations. Enhance the expansion of cleaner energy technology power systems activities in southern and western regional African countries, eastern Europe, the Pacific Rim, Russia and Newly Independent States, South Asia/Near East, western Europe, and the Western Hemisphere. Promote the deployment of carbon capture and storage technologies worldwide. Influence opportunities for cleaner power systems and clean fuels from coal in selected countries. Initiate the implementation of Clean Energy/Industrial Ecology Projects in developing countries as a means of mitigating CO_2 emissions growth as these countries expand electrification. *Participants to be determined.*

(dollars in thousands)

FY 2004	FY 2005	FY 2006

In FY 2005, continue Fossil Energy's commitment to the International Energy Agency (IEA) program support. Continue to provide leadership, direction, cooperation and coordination of office activities with other Federal agencies, state and local governments, energy trade associations, and the energy industry. Continue preservation and enhancement of active relationships with national and international organizations such as the World Energy Council (WEC), United States Energy Association (USEA), Southern States Energy Board (SSEB), and universities and other non-governmental organizations. Enhance the expansion of cleaner energy technology power systems activities in southern and western regional African countries, eastern Europe, the Pacific Rim, Russia and Newly Independent States, South Asia/Near East, western Europe, and the Western Hemisphere. Promote the deployment of carbon capture and storage technologies worldwide. Influence opportunities for cleaner power systems and clean fuels from coal in selected countries. Initiate the implementation of Clean Energy/Industrial Ecology Projects in developing countries as a means of mitigating CO_2 emissions growth as these countries expand electrification. *Participants to be determined.*

FY 2004 funding continued support of Fossil Energy's commitment to the International Energy Agency (IEA) program effort. Provide leadership, direction, cooperation and coordination of office activities with other Federal agencies, state and local governments, energy trade associations, and the energy industry. Preserved and enhanced active relationships with national and international organizations such as the World Energy Council (WEC), United States Energy Association (USEA), Southern States Energy Board (SSEB) and universities and other non-governmental organizations. Focused on expanding cleaner energy technology power systems activities in Southern and Western regional African countries, Eastern Europe, the Pacific Rim, Russia and Newly Independent States, South Asia/Near East, Western Europe, and the Western Hemisphere. Determined opportunities for cleaner power systems and clean fuels from coal in targeted countries. *Participants to be determined.*

- **Focus Area for Computational Energy Science**..... **4,905** **3,945** **4,000**

  - **Focus Area for Computational Energy Science**..... **4,856** **3,906** **3,960**

    In FY 2006, NETL will continue the development of virtual simulations capability to model the performance of advanced power plant systems using mathematical computational simulations and computer-based models. This capability will greatly accelerate development time and significantly reduce the costs required to design viable zero-emissions coal energy options. NETL will continue to apply, analyze and evaluate simulators of high efficiency and near-zero emission processes at both the individual component level and at the integrated overall system level to assist in their design and establish performance parameters. Continue the application of steady-state process simulations that use coal gasification, gas turbines, and fuel cell subsystems. Using these capabilities, initiate analyses of fuel cell-gas turbine hybrid systems to provide detailed information on the complex interaction between fuel cells and gas turbines that have been coupled together to achieve ultra high efficiency in electrical

generation. Continue to extend these steady-state capabilities to develop simulations of dynamic or time-varying models. The ability to study these advanced power generation systems as they vary in time will help in optimizing operations such as startup, shutdown, and system upsets. At a reduced level of effort, continue the Superconducting Science Consortium support activities for advanced simulations by providing high performance computing, internet access, technical support and visualization development. *Participants include: NETL, CMU, West Virginia U, State of WV, PSC, and U of Pittsburgh.*

In FY 2005, NETL continue development of virtual simulations capability using mathematical computational simulations and modeling to accelerate development time and reduce costs of technology systems that have high efficiencies with near-zero emissions. Begin to apply the virtual integrated simulators of high efficiency and near-zero emission processes to study proposed systems and evaluate their design and performance. Analyze and evaluate these advanced processes, using the advanced simulation capability, at both the individual component level and overall system level. Complete the initial application of process simulation of high efficiency and near-zero emission process incorporating MFIX-based component model describing an advanced gasification process to provide detailed information describing the gasification process. Complete the initial application of process simulation of high efficiency and near-zero emission process based on fuel cell/gas turbine hybrid system which incorporates a detailed fuel cell component model that will provide detailed information describing fuel cell stack performance. At a reduced level of effort, continue the Supercomputing Science Consortium support activities in advanced simulations by providing high performance computing, internet access, technical support and visualization development in direct support of virtual integrated simulators. Complete a virtual integrated simulation of a high efficiency and near-zero emission process, such as a hybrid or advanced gasifier, to demonstrate the ability to simulate a dynamic coupled system. *Participants included: NETL, CMU, U. of WVU, State of WV, PSCC, U. of Pittsburgh.*

In FY 2004, NETL continued development of virtual demonstration capability using mathematical simulations and modeling to improve the speed and reduce the costs of technology systems that have high efficiencies with near-zero emissions. Developed simulations that couple fluid flow, chemical reactions, heat generation, heat transfer, and electrochemistry for modeling multi-dimensional transients in fuel cells, heat engines, gasifiers, and other crucial unit processes in advanced Zero-emission compatible plants. Completed CFD models of fuel cells, turbines, and gasifiers. Enhanced multi-phase flow models (MFIX) with meshing, large eddy simulations and chemistry and heat transfer improvements. Integrated subsystem component modules and dynamic system models to simulate a first case Zero-emission compatible plant. Continued to perform data reduction and data extraction on extensive information available from simulations of advanced energy plants for incorporation into codes being developed. Continue supercomputing Science Consortium supporting activity in advanced simulations by providing high speed computing, technical

support, and visualization simulations. *Participants include: Carnegie Mellon University, West Virginia University, Pittsburgh Supercomputing Center, University of Pittsburgh.*

- **Program Support**..... **49** **39** **40**

  Fund technical and program management support.

University Coal Research..... **2,863** **2,958** **3,000**

- **University Coal Research** **2,833** **2,928** **2,970**

  In FY 2006, the University Coal Research (UCR) Program plans to continue to support grants at U.S. colleges and universities by emphasizing longer-term research for achieving Fossil Energy's strategic objectives. Critical key research areas that accelerate technology development and seek to identify breakthrough technologies for the next century will be supported. Key research areas that will be supported will include: advanced power systems including FutureGen, the hydrogen from coal initiative, global climate change, control of coal-based mercury emissions, development of advanced materials, sensors and controls, fuel cells, and the utilization of coal-by-products.

  As in past years, support will continue in all three areas of the UCR Program: the Core, Innovative Concepts Phase-I and, Innovative Concepts Phase-II areas. Under the Core area, the program will continue to encourage collaboration through joint proposals involving university/industry teams. Core Program grants from about $200,000 to $400,000 each will be awarded. The number of grants will be determined by the number of meritorious proposals submitted.

  Exploration of novel approaches and innovative concepts developed in other scientific and technological areas that assist in developing breakthrough technologies for coal utilization will also be continued in the Innovative Concepts Phase-I and Phase-II areas. Approximately six, $50,000, one year, Innovative Concepts Phase I grants could be awarded. Further, plans are to continue the Innovative Concepts Phase II Program where one or more Phase I projects can be selected for a $200,000 Phase-II grant award. *Participants to be determined.*

  In FY 2005, the University Coal Research (UCR) Program will continue to support grants at U.S. colleges and universities by emphasizing longer-term research for achieving Fossil Energy's strategic objectives. Critical key research areas that accelerate technology development and seeking to identify breakthrough technologies for the next century will be supported. The key research areas that will be supported will include: Zero-emission plants, hydrogen initiative, global climate change, coal-based mercury emissions, materials, sensors and controls, and coal by-product utilization for the measurement, characterization, and the development of cost-effective control technologies. *Participants to be determined.*

  FY 2004, funding supported grants at U.S. universities which emphasize longer-term research that will accelerate technology development and identify breakthrough technologies for the next

(dollars in thousands)

FY 2004	FY 2005	FY 2006

century; focus on scientific and technological issues that are key to achieving FE's strategic objectives in the areas of: the Core, Innovative Concepts Phase-I and Innovative Concepts Phase-II. Support is continuing in many critical key research areas which include: FutureGen, global climate change, materials, sensors and controls, and fuel cells. Breakthrough technologies for the measurement, characterization, and the development of cost-effective control technologies for fossil coal-based carbon dioxide and mercury emissions are also being supported. The breakthrough technologies identified included materials for hydrogen storage, high temperature material coatings, computer-aided design of high temperature materials, advanced gas sensors using carbon nanotubes, diode laser sensors for temperature and gas composition for gasifiers, novel materials for carbon dioxide and hydrogen separation, and novel solid oxide sealing systems. Twenty-two universities in 18 states were involved as part of the $2.8 million grant program in FY 2004. *Participants: Various colleges and universities.*

Exploration of novel approaches and innovative concepts developed in other scientific and technological areas that assist in developing breakthrough technologies for coal utilization will be continued in the Innovative Concepts Phase-I and Phase-II areas. Approximately six, $50,000, one year, Innovative Concepts Phase-I Projects could be awarded. Further, plans are to continue the Innovative Concepts Phase II program. *Participants: Various colleges and universities.*

▪ **Program Support**	**30**	**30**	**30**

Fund technical and program management support.

HBCUs, Education and Training	**954**	**986**	**1,000**
▪ **HBCUs, Education and Training**	**944**	**976**	**990**

FY 2006 funding will be used to conduct research activities with HBCU and other minority institutions and support an HBCU annual technology transfer symposium. *Participants to be determined.*

FY 2005 and FY 2004 funding continued research activities at HBCU and other minority institutions and supported HBCU annual technology transfer symposium. *Participants included: Various colleges and universities.*

▪ **Program Support**	**10**	**10**	**10**

Fund technical and program management support.

Total, Advanced Research	**37,533**	**42,699**	**30,500**

Explanation of Funding Changes

	FY 2006 vs. FY 2005 ($000)
Coal Utilization	
▪ No funding is requested for the Arctic Energy Office and the Center for Zero Emission Coal Research. Activities in support of the Strategic Center for Zero Emissions Coal Research will continue in FY 2006 with funds that were forward funded in FY 2005	-9,552
Materials	
▪ Decreased funding for developing advanced materials for ultra supercritical boilers and steam turbines	-2,848
Technology Crosscut	
▪ Activities continued at an increased level of effort	+145
University Coal Research	
▪ Increased funding for research grants	+42
HBCUs, Education & Training	
▪ Increased funding for education and training	+14
Total Funding Change, Advanced Research	**-12,199**